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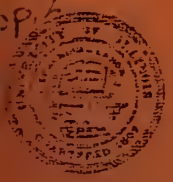

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The Measurement of Physiological Symptoms in Work Stress Research: A Critique

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ABSTRACT

There has been considerable growth in the number of studies focused on the relationship between stress at work and a variety of physiological symptoms, especially cardiovascular irregularities, abnormal levels of biochemicals in the blood and urine, and gastrointestinal disorders. Many of these studies, however, have used inadequate methods and procedures for measuring those symptoms. Consequently, the results and conclusions of these studies are often invalid or, at best, questionable. The purpose of this paper is to critique the prevailing methods and procedures used in the measurement of physiological symptoms in work stress research and to suggest needed improvements.

INTRODUCTION

During the past decade, there has been a growing interest in the literature on stress at work, both from a theoretical point of view (e.g., McGrath, 1976; Cohen, 1980; Schuler, 1980) and an empirical point of view, particularly the impact of work stress on the emergence of physiological symptoms and related personal and organizational outcomes (e.g., Beehr & Newman, 1978). Stress at work has been singled out as an important area of investigation for several reasons, among them: the significant amount of time that people spend at their work places, the importance of work to people as a fundamental means for implementing and fulfilling their aspirations and expectations (Hackman & Oldham, 1980; Yankelovich, 1979), and the possible legal and productivity implications of work stress for organizations (for a review, see Beehr & Schuler, 1982).

Stress at work is often associated with a variety of physiological symptoms (Eliot, 1979; Frankenhaeuser, 1975; McQuade & Aikman, 1974; Morse & Furst, 1979; Weiner, 1979). Measures of these physiological symptoms are increasingly being used as indices of the degree of stress at work. In general, research studies of the work stress-physiological symptoms relationship have focused on the following physiological symptoms:[1]

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[1]For a listing of these studies and the focal symptoms investigated, see Table 1.

1. Cardiovascular symptoms (the most popular), primarily increased heart rate and blood pressure.[2]
2. Biochemical symptoms, such as abnormal levels of uric acid, blood sugar, steroid hormones (especially uric acid), and, most of all, cholesterol and catecholamines (especially adrenaline and noradrenaline); and
3. Gastrointestinal symptoms, primarily peptic ulcer.

Physiological measures of stress, in contrast to self-report psychological measures of stress, as well as behavioral measures of stress, are usually viewed as providing "harder" or more "objective" data, because they are much less susceptible to contextual factors, both internal to the organization (e.g., the reward and sanction system) and external to the organization (e.g., the condition of the labor market), which, in turn, affect work attitudes, especially perceptions regarding the degree of stress, and such work-related behaviors as absenteeism and turnover. On the other hand, the common assumption regarding the "objectivity" of physiological measures is often less than accurate. Similar to the psychological and behavioral measures of stress, the physiological measures of stress are also seriously vulnerable to a variety of potentially threatening factors.

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[2]Heart attack is another cardiovascular symptom that interests scholars and researchers. However, as Beehr and Newman (1978) have pointed out, most work stress-heart attack research has focused instead on a number of related "risk factors," such as blood pressure, pulse rate, or cholesterol; factors identified as contributors to coronary heart disease. The reason is that the rate of heart attacks among most employee samples is too low to permit efficient study of the work stress-heart attack relationship.

In this paper, we will attempt to show that the methods and procedures typically used for measuring the identified physiological symptoms are often inadequate, and will only provide valid evidence regarding the impact of stress at work when these potentially threatening factors are controlled or accounted for in the measurement process. We will also attempt to show how, when improved methods and procedures are used, the validity of work stress research can be greatly improved.

CATEGORIES OF STUDIES OF WORK STRESS AND PHYSIOLOGICAL SYMPTOMS

Based on their research designs, studies of work stress and physiological symptoms can be divided into three major categories, as follows:

1. Studies that are cross-sectional in nature (primarily correlational) and have examined the relationships of different stressors at work (usually as they are perceived by subjects) and certain physiological symptoms (sometimes among different occupational groups) at <u>one</u> point in time;
2. Studies that have examined the existence or nonexistence of physiological symptoms of subjects in stressful versus nonstressful conditions (often with the use of control groups) over a relatively <u>short-time interval</u> (e.g., day versus night, or work day versus rest day); and
3. Longitudinal studies that have examined the existence or nonexistence of physiological symptoms of subjects under different levels of stress at work over a period of several months or years (at times with the use of control groups).

In contrast to the cross-sectional studies that have generally defined the level of work stress (high or low) according to the perceptions

of subject participants, the short-time interval and longitudinal studies have generally relied on the "objective" assignments or assessments of researchers to define the level of stress. Studies of work stress which fall within each of these design categories are now briefly identified.

Cross-Sectional Studies

Brousseau and Mallinger (1980) examined the moderating effect of locus of control on the relationships between occupational stress and blood pressure and ECG among 101 dentists. Orth-Gomér and Ahlbom (1980) examined the impact of psychological stress at work, family life, and education upon the level of blood pressure, cholesterol, tryglycerids, glucose, and uric acid. House, McMichael, Wells, Kaplan and Landerman (1979) investigated the level of blood pressure and the existence of peptic ulcer among blue collar workers of a large manufacturing plant. Aunola, Nykyri, and Rusko (1978, 1979) compared the heart rate of skilled and semi-skilled men and women employees in a Finish manufacturing company.

Caplan, Cobb, and French (1979) examined the impact of the workload of white-collar employees on the level of cortisol in the blood. Waldron (1978) compared the level of blood pressure and heart rate between samples of housewives and employed women 40-59 years of age. Howard, Cunningham, and Rechnitzer (1976) examined how blood pressure related to Type A behavior among top managers. Caplan, Cobb, French, Harrison, and Pinneau (1975) explored the impact of stress at work on the level of cortisol, cholesterol, blood pressure, uric acid, thyroid hormones, and peptic ulcer among different occupational groups (i.e.,

those in factory jobs, in contrast to those in scientific/professional occupations). Hennigan and Wortham (1975) investigated the impact of the job activities of line and staff managers on heart rate. Reeder, Schrama, and Dirken (1973), based on a cooperative international study, focused on the effect of subjective and objective stress at work on the level of cholesterol.

In another single-factory study, Schar, Reeder, and Dirken (1973) examined the impact of stress at work on blood pressure, cholesterol, sugar in the urine, and protein urine. Shirom, Eden, Silberwasser, and Kellermann (1973) investigated the relationships among several job stressors (e.g., role overload and role conflict) in five occupational categories on the level of cholesterol, blood pressure, pulse rate, glucose, and uric acid. Caplan (1971) examined the impact of several role stressors (e.g., role ambiguity and role overload) among administrators, engineers, and scientists on the level of cholesterol, blood pressure, uric acid, cortisol, and glucose. French and Caplan (1970) investigated the impact of subjective and objective occupational stress on the level of heart rate, blood pressure, cholesterol, uric acid, and glucose. Sales (1970) examined the moderating effect of subjects' personalities on the relationships between perceived role overload, role underload, and heart rate.

Dunn and Cobb (1962) compared the prevalence of peptic ulcer in foremen versus executives and craftsmen. In a similar study, Gosling (1958) examined the frequency of peptic ulcer among different occupational groups, such as foremen, clerks, executives, and managers. Marchbanks, Hale, and Ellis (1963) measured the difference in cortisol

levels in the urine of pilots after a mission versus pilots on off-day status.

Finally, Dougherty (1967) and Crump, Cooper, and Maxwell (1981) focused on the stressful work of air traffic controllers. Dougherty (1967) compared the level of blood pressure, ECG, and urine glucose and protein among air traffic controllers, journeymen, radar controllers, and non-air traffic controllers. Crump, et al. (1981) investigated the relationships between subjective job stressors, individual differences, and demographic variables, and air controllers' blood pressure and cholesterol, as part of a coronary disease risk index.

Short-Time Interval Studies

Jenner, Reynolds, and Harrison (1980) analyzed the catecholamine excretion rates of men living in 12 villages, according to occupation (non-manual, manual, and professional or managerial) and day of week (work day versus rest day). Frankenhaeuser and Gardell (1976) and Johansson, Aronsson, and Lindström (1978) compared, during both work and free hours, the urinary excretion of adrenaline and noradrenaline between workers with repetitive and nonrepetitive jobs. Dutton, Smolensky, Leach, Lorimor, and Hsi (1978) collected hourly urine samples from firemen and paramedics during work and nonwork days in order to examine the impact of physical and emotional manifestations of stress at work on catecholamine levels.

Barnard and Duncan (1975) used an ECG to explore the impact of emergency situations on firefighters. Analysis of the ECG results was made before the alarm sounded, and then every minute after the alarm sounded until the time the men returned to their station. In a similar

study, Kuorinka and Korhonen (1981) continuously measured the ECG and pulse rate of firemen at work over a 24-hour period. Caplan and Jones (1975) examined the level of heart rate before a stressful situation (a computer shutdown) and during a period of relatively low level of work stress. Rubin (1974) measured the level of cortisol and catecholamines of pilots and radar intercept officers before a mission (non-flying control day) versus after a mission. Reynolds (1974) examined, during six weeks before and after launching a space vehicle for moon landing, the effect of this event on the ECGs of employees that had a vital role in the launch versus employees who had no direct role in the launch. Bourne, Rose, and Mason (1968) collected urine samples from soldiers in Vietnam over an 18-day period to examine the impact of expected attack by the Viet Cong on the level of catecholamines in the urine. Hale, Williams, Smith, and Melton (1971a) examined the level of cortisol and catecholamines of air traffic controllers at O'Hare Airport during two randomly scheduled five-day periods. In another study, Hale et al. (1971b) examined the long-term effects of intermittent mid-shift (2400-0800 hours) work on the level of urinary cortisol, catecholamines, and urea. Finally, Grandjean, Wotzka, Schaad, and Gilgen (1971) examined the impact of air controllers' fatigue on urinary catecholamines through a comparison of subjects' level of catecholamines during three different situations at work: during air traffic control, during ground traffic control, and during ordinary office work.

Longitudinal Studies

During a two-year period, Cobb and Kasl (1972) investigated changes in employees' blood pressure, cholesterol, and uric acid in

two manufacturing plants before closing and after closing. Also over a two-year period, Gore (1978) explored the changes in blood cholesterol before and after a shut-down of two factories, one urban and the other rural.

Rubin and Rahe (1974) tested for four months the impact of a Navy underwater demolition team (UDT) training program on the level of cortisol, cholesterol, and uric acid.

Cobb and Rose (1973) examined the development of high blood pressure and peptic ulcer among air traffic controllers and first-class airmen over several years. Astrand, Fugelli, Karlsson, Rodahl, and Vokac (1973) examined over a winter and summer season the level of heart rate and catecholamines in the urine of fishermen during a work day at sea and after a night of rest. Chapman, Reeder, Massey, Borun, Picken, Browning, Coulson, and Zimmerman (1966) examined for 13 years the impact of general stress at work on the level of cholesterol, blood pressure, and urine protein. Friedman, Rosenman, and Carroll (1958) examined for six months the level of cholesterol and blood clotting among 40 accountants under increasing work-load conditions (when tasks deadlines approached).

METHODOLOGICAL PROBLEMS

Despite the relatively large number of studies, the impact of work stress on the emergence of physiological symptoms is not clear. A significant portion of the results of these studies have been found to be weak or inconclusive (Kasl, 1978).

One of the possible sources for these weak, inconsistent results might well be the typically questionable methods and inadequate procedures used to measure physiological symptoms. There has been, we believe, a tendency in work stress research to neglect, in the process of physiological measurement, potential threatening factors that might unexpectedly or unknowingly affect the level of the focal physiological symptom. The fact is that a significant number of researchers, as can be seen in Table 2, have paid little, if any, systematic attention to the potential effects of such factors. Surprisingly, the literature has not focused seriously on these measurement issues. Some scholars, such as Kasl (1978), McGrath (1970, 1982), Shapiro, Benson, Chobanian, Herd, Julius, Kaplan, Lazarus, Ostfeld, and Syme (1979), and Wolf, Almy, Bachrach, Spiro, Sturdevant, and Weiner (1979), have identified a few of the methodological shortcomings of physiological measurement in stress studies. But, as yet, there have been few attempts to correct for these shortcomings. In essence, it seems to us that the professional journals in the health and social sciences, have paid much too little attention to the critical elements of physiological measurement in the work stress area. The professional journals of these fields have generally imposed rigid requirements on matters of research design and measurement in many areas of investigation, but have not imposed these same requirements on the physiologically-biased studies of stress at work.

The literature indicates the importance of three major categories of factors that might affect the validity of physiological measurement. We shall now briefly describe them.

1. Stable or Permanent Factors - these factors, which represent differences among individuals and groups in their susceptibility to certain physiological symptoms, include familial or genetic tendency, race, sex, age, and diet or habitual nutrition. To illustrate: people with a familial tendency to high blood pressure appear to develop higher levels of blood pressure than people who do not have such a familial tendency; or people with blood group 0 are about 37 percent more likely to develop duodenal ulcer than are people of other blood groups.

2. Transitory Factors - these factors, which are time and situation-specific, such as time of day, room temperature, room humidity, postural position of subject, and physical exertion, consumption of caffeine and nicotine before or during the time of measurement, can have an effect on measurement results. For example, the level of cholesterol tends to be higher while standing up than while sitting down; physical exertion before or during measurement tends to increase urinary noradrenaline; drinking coffee (caffeinated versus decaffeinated) or smoking before or during measurement tends to increase the level of cardiovascular activity.

3. Procedural Factors - in contrast to the above two sets of factors, which deal with the external or contextual (to measurement) factors that might affect subjects' levels of physiological symptoms, these factors are focused on the procedural problems of measurement, such as the number of times physiological measurements are made or the amount of time between measurements. To illustrate, blood pressure is not a static measure. There is a natural variation in the cardiovascular

system. Thus, a single measure of blood pressure is not a reliable indicator. Instead, several visits with several measures per visit are required for an accurate assessment.

A major premise of this paper, as noted earlier, is that there is a clear tendency among studies of work stress and physiological symptoms to not control for the above factors or to take into account their potential effects on physiological symptoms. Yet one might ask whether or not, or to what extent, the threats of the above factors are relevant to all work stress research or might be restricted to studies with specific research designs. Because of the importance of this issue, we will address it next.

Generally, the potential threats of the above three sets of factors appear to be more obvious and straightforward in regard to the cross-sectional studies. Because of their design characteristics, the cross-sectional studies are more vulnerable to the effects of inadequate measurement procedures. For example, measuring blood pressure once instead of several times, as required for accuracy, could rather easily confound the results and conclusions of these studies, as could not controlling or examining the potential effects of the threatening factors on the procedures used.

Cross-sectional studies are also more vulnerable to the effects of transitory factors. For example, the consumption of caffeine before or during measurement tends to affect the level of cardiovascular activity. Thus, one can expect to find, under the reasonable premise that some subjects will consume caffeine before measurement, while others will not, different levels of cardiac activity unrelated (at least to some extent) to the level of stress at work.

Finally, stable or permanent factors might also obscure the results of the work stress-physiological symptoms relationship in cross-sectional studies. It might be, for example, that people with a lower physiological tolerance to stress, due to such factors as familial tendency, age, or nutritional habits, will find it more difficult than those with a higher physiological tolerance to stress to adjust to certain work demands. Thus, although the objective level of work stress might be the same or similar for both groups, the group with the lower physiological tolerance to stress would probably perceive a higher level of work stress than the other group. (Recall that most of the cross-sectional studies are based on the self reports of subjects to perceived levels of stress.) Such results, of course, can lead to false conclusions and interpretations about the level of work stress, as well as the causal relationship between work stress and the focal physiological symptom or symptoms.

The issue seems to be more complicated when considering the short-term interval or longitudinal studies. Specifically, a claim could be made that the potential threats of the three sets of factors would be diminished or significantly reduced for these studies, under the assumption that they are appropriately designed, so that comparisons could be made of the focal physiological symptom or symptoms under different levels of work stress over different periods of time, or of the focal physiological symptom or symptoms between one or more experimental groups (that experience stress) and one or more control groups (that do not experience stress). The argument follows that even if such threatening contextual factors as time of day (as a transitional

factor) or familial tendency (as a stable or permanent factor) are in existence, they will tend to be similar or randomly distributed in both the experimental and control groups and/or between and among the different points of measurement over time. On this basis, one can study the aggregate effects of the examined stressors on the focal physiological symptom or symptoms beyond the possible biasing effects of the threatening factors.

Although it is true that the use of a control group or groups and/or several measurements under different levels of stress over extended time periods provides some important methodological advantages, it is far from true that these advantages lead to a complete or comprehensive resolution to the potential effects of the threatening factors. Above all, it is clear that experimentally-designed studies or studies with a variety of time measurements cannot remove the procedural problems often encountered in the measurement of physiological symptoms. That is, whatever the results of a study, they cannot be considered as valid, regardless of the research design that has been used, unless the procedures of measurement are valid.

In addition, the threat of the contextual factors on the validity of results may not be eliminated by the use of an "appropriate" research design. First, the assumption that such transitory factors as room temperature, the subject's postural position, or time of measurement will be similar in the different conditions or points of measurement, may not hold up in practice. The point is that, since scholars tend <u>not</u> to be aware of the need to equalize these factors in the different

conditions of measurement, it can be expected that such factors as room temperature, room humidity, or time of measurement will be dissimilar in the different conditions of measurement, at least in a portion of the studies. Suppose, for example, that the control group in a study is located in a different location than the experimental group and the research crew is small and restricted in time. Under such conditions, there is a relatively high probability that the measurement of the two groups will be taken at different points of time (e.g., the experimental group in the morning and the control group in the afternoon or evening).

It should be emphasized that we are not implying that such threatening factors have not, mainly by chance, been similar or randomly distributed in the different conditions of measurement. However, the fact that researchers have not usually been aware of the necessity to control these factors or to examine their potential impact, and thus have failed generally to provide us with necessary information about (for example) the time of measurement or the room temperature in the different conditions of measurement, raises doubts concerning the validity of a good many work stress studies.

Second, it is true that, with the random selection of subjects, one can expect to find similar percentages of potentially threatening traits or habits in the experimental and control groups. Yet, since the actual level of such habits as coffee drinking and smoking, for example, is often situationally determined (i.e., by the stressfulness of the experimental condition), the underlying assumption of similarity can be questioned. That is, one might expect to find a similar number of people

in both groups that can be labeled as potential coffee drinkers or smokers. However, one might also expect to find systematic differences between the two groups in regard to the actual amount of coffee drinking and smoking. This would be due mainly to the fact that the potential coffee drinkers and smokers in the experimental group had implemented their coffee drinking and smoking habits during the period of exposure to work stress (as a stress coping mechanism) significantly more than the potential coffee drinkers or smokers in the control group, who were (by definition) not exposed to stress.

A similar argument can be made in regard to studies that measure subjects' physiological symptoms under different levels of work stress over time. Here, again, the major issue is that more subjects out of the potential group of coffee drinkers and smokers will probably be more willing to implement their potential habits of coffee drinking and smoking under stressful conditions (e.g., during a working day) than under more calm situations (e.g., during a rest day). These differences in the number of coffee drinkers and smokers, or in the amount of coffee drinking and smoking between or among the different conditions of measurement, as described above, can obscure the results and threaten their validity.

Further, suppose that there is a situation in which there is no significant relationship between work stress and, say, a focal cardiovascular symptom. One still might find significant differences in the examined cardiovascular symptom between the experimental group and the control group, in the hypothesized direction, due to the differences in the levels of coffee drinking and smoking between the two groups.

That is, the findings might show higher levels of the given cardiovascular symptom in the experimental ("stressful") group, due to higher levels of coffee drinking and smoking in the experimental group versus the control group. To conclude that the differences in the levels of the examined symptom are due to the impact of work stress, as hypothesized, is, in this case, incorrect and invalid.

Third, there is a general tendency in the literature to ignore the possible interactions between the potentially threatening factors (especially permanent or stable factors, such as age or familial tendency) and work stress; interactions that might create new entities of influence on the focal physiological symptom. To illustrate, the blood pressure of people with a familial or genetic tendency toward high blood pressure might be, under stressful situations, significantly higher than under nonstressful situations, because of the possible interactive effects between stress and the tendency to high blood pressure. Thus, in a study in which a relatively large portion of the subjects have a familial tendency to high blood pressure, the results might show differences in blood pressure between the experimental ("stressful") group and the control ("nonstressful") group, or between high versus low levels of stress at different periods of time. In this case, the results, unless confirmed after controlling or taking into account the potential effects of the tendency to high blood pressure, might lead to invalid conclusions about the net effect of work stress on blood pressure, while ignoring the realistic possibility that it is the interaction between work stress and the tendency to high blood pressure that causes the results.

From all the above, it can be concluded that studies of work stress and physiological measurement should pay careful attention to the potential effects of the different threatening factors, regardless of the research design used.

This paper will not attempt to examine the relative importance or impact of the suggested threatening factors on the identified physiological symptoms. That is, we will not analyze the empirical studies of work stress that are cited in this paper in order to attempt to find out, if, and to what extent, the different factors actually affected the physiological symptoms. Because there are so many serious methodological obstacles in the work stress research area, it would be nearly impossible, in our opinion, to conduct such an investigation. We will elaborate on this point in the discussion and conclusions section of this paper.

In the following sections, we will review, under the three identified categories (stable or permanent factors, transitory factors, and procedural factors), the major physiological symptoms that have been examined in the studies of stress at work. Specifically, the focus will be on (1) blood pressure and cardiac activity (heart rate and ECG), (2) cholesterol in the blood, (3) urinary catecholamines,[3] and (4) peptic ulcer. These different physiological symptoms will be reviewed, in two stages, under the previously identified categories of factors: First, we will address the potential impact of relevant factors on the focal

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[3]Although cholesterol and catecholamines can be collected from other systems in the body, all of the described work stress studies have collected cholesterol from the blood and catecholamines from the urine. Thus, our analysis and critique in this paper will relate to blood cholesterol and urinary catecholamines.

physiological symptom. Then, we will examine whether relevant work stress studies have considered these factors in the process of measuring the focal physiological symptom.

BLOOD PRESSURE/CARDIAC ACTIVITY[4]

1. Stable Or Permanent Factors That Might Affect Blood Pressure/Cardiac Activity

Familial Tendency, Race, Sex, And Age--Why They Have To Be Taken Into Account. It seems to be a well-established fact that familial or genetic tendency affects the level of blood pressure and cardiac activity (Johnson, Epstein, & Kjelsberg, 1965; Light, 1981; Miall, Heneage, Khosla, Lovell, & Moore, 1967; Perera, Clark, Gearing, & Schweitzer, 1961; Schweitzer, Gearing, & Perera, 1967; Shapiro, 1973; Zinner, Levy, & Kass, 1971). Although the evidence is inconclusive, Siddle and Turpin (1980) concluded that race, sex, and age do appear to affect blood pressure and cardiac activity. A question has been raised as to whether genetic factors versus social or demographic factors could account for the above described similarities in cardiac activity among relatives, as well as the differences in cardiac activity based on race, sex, and age (e.g., Morse & Furst, 1979; Weiner, 1979). For our purposes, this debate seems irrelevant; if there is evidence that genetic factors affect cardiac activity, or even if there is only general evidence that race, sex, and age influence cardiac activity, the impact of such factors should be examined and taken into account.

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[4] Since blood pressure and cardiac activity are highly correlated, they will be discussed jointly.

Health Disorders--Why They Have To Be Taken Into Account. Health disorders, especially heart disease, should be considered in work stress research, since these disorders may significantly alter blood pressure and cardiac activity without being associated with environmental or occupational stressors (Jennings, Berg, Hutcheson, Orbist, Porges, & Turpin, 1981).

Has Research Considered The Above Factors?

Familial Tendency and Health Disorders. Only a few studies have taken into consideration the effects or possible effects of familial tendency on cardiovascular symptoms (Caplan, 1971; Crump, Cooper, & Maxwell, 1981; Orth-Gomér & Ahlbom, 1980; Schär, Reeder, & Dirken, 1973).

Some studies (8 out of 28, or about 30 percent of the total) have ruled out or taken into consideration the possible impact of the subject's health condition on cardiovascular symptoms (Barnard & Duncan, 1975; Caplan, 1971; Chapman, Reeder, Massey, Borun, Picken, Browning, Coulson, & Zimmerman, 1966; Hennigan & Wortham, 1975; Kuorinka & Korhonen, 1981; Orth-Gomér & Ahlbom, 1980; Reynolds, 1974; Warheit, 1974). However, these studies tend to be vague about the definition and measurement of the term "health condition."

Race and Sex. While Kasl (1978) has stated that the studies of stress at work and cardiovascular health have dealt almost exclusively with white males, there have been a few studies that have separately examined both men and women (e.g., Aunola, Nykyri, & Rusko, 1978; Harburg, Blakelock, & Roeper, 1979). The picture is less clear in relation to race. A high percent of the studies have not mentioned whether their subjects were white or black (or otherwise), and, if so, in what

proportion (Astrand, Fugelli, Karlsson, Rodahl, & Vokac, 1973; Barnard & Duncan, 1970; Caplan & Jones, 1975; Chapman, et al., 1966; Cobb & Kasl, 1972; Crump, et al., 1981; Dougherty, 1967; French & Caplan, 1970; Hennigan & Wortham, 1970; Howard, Cunningham, & Rechnitzer, 1976; Orth-Gomér & Ahlbom, 1980; Rose, Jenkins, & Hurst, 1978; Sales, 1970). One might suspect that blacks would have taken part in some of these studies, even if they represented a minority. Up until now, however, it seems that only Harburg, et al. (1979) examined the race variable in their study on blood pressure under work stress.

Age. About sixty percent (16 out of 28) of the identified work stress studies have either ruled out or taken into account the possible influence of age on blood pressure/cardiac activity (Astrand, et al., 1973; Aunola, et al., 1978, 1979; Brousseau & Mallinger, 1981; Caplan, 1971; Caplan, Cobb, French, Harrison, & Pinneau, 1975; Cobb & Rose, 1973; Crump, et al., 1981; Dougherty, 1967; Harburg, et al., 1979; Hennigan & Wortham, 1975; Kuorinka & Korhonen, 1981; Reeder, Schrama, & Dirken, 1973; Reynolds, 1974; Schär, et al., 1973; Shirom, Eden, Silberwasser, & Kellermann, 1973; Warheit, 1974).

2. Transitory Factors That Might Affect Blood Pressure/Cardiac Activity Temperature, Humidity, Postural Change, Drinking, Smoking, and Exercise--Why They Have To Be Taken Into Account. It has been well demonstrated that such factors as temperature, humidity, postural change, consumption of caffeine, nicotine, and alcohol before or during measurement, exercise before or during measurement, time of day, and even time of the last meal, influence the level of cardiac activity (Berne & Levy,

1967; Cohen & MacDonald, 1974; Elliott & Thynsell, 1968; Jennings, et al., 1981; Malmstrom, 1971; Semler, 1965; Siddle & Turpin, 1980). For example, a change in room temperature from one day to the next, or during the same day of measurement, can lead to different results in regard to the measured cardiovascular symptoms, but unrelated to the stressful events being investigated.

Has Research Considered The Above Factors?

In general, studies of work stress have paid little or no attention to the possible impact of these transitory factors on the cardiovascular system. Actually, only Caplan, et al. (1975) controlled the consumption of caffeine and nicotine. The possible impact of postural position has been controlled only in a few studies (specifically 5 out of 28 or about 20 percent). Rose, et al. (1978), for example, took the mean level of blood pressure after examining it in three positions--lying down, sitting up, and standing up. Orth-Gomér & Ahlbom (1980) took blood pressure in two positions, supine and sitting. Caplan and Jones (1975), Caplan, et al. (1975) and House, McMichael, Wells, Kaplan, and Landerman (1979) have observed either the level of heart activity or blood pressure in all of their subjects in a sitting position. It might be that other studies, too, have unintentionally controlled for the possible effects of postural changes or postural inconsistency by measuring the cardiovascular symptoms under one position (e.g., sitting). However, these studies do not inform us as to which postural position was used in taking the measurements. Thus, the postural factor remains as a possible threat to external validity.

3. Procedural Factors In Measurement That Might Affect Blood Pressure/ Cardiac Activity

Here we will examine the impact of two major problems in the measurement of blood pressure and how work stress studies have considered or coped with them. First, we will focus on how the measurement problem relates to blood pressure variability and then with the issue of direct versus indirect measurement of blood pressure.

The Problem Of Variability Of Blood Pressure. As noted earlier, there is a natural variation in the cardiovascular system (Carey, Reid, Ayers, Lynch, McLain, & Vaughn, 1976; Rosner & Polk, 1979, 1981; Stern, Ray, & Davis, 1980). A normal individual's blood pressure can vary as much as 30 mm Hg during a one-minute recording using a direct blood pressure technique (Tursky, 1974). Thus, because of this inherent variability in blood pressure, a single measure of blood pressure is not sufficiently reliable for identifying hypertension.

Rosner and Polk (1979, 1981) concluded, based on their experiments, that three visits with two measurements per visit were sufficient for an accurate assessment of hypertension. It might be that other scholars would argue for a different schedule of measurements. The important conclusion, however, is that blood pressure should be measured several times, with sufficient intervals of days between measurements. It is also important that the measurements within the same day or visit be taken at appropriate time intervals between them (e.g., an hour). As Stern, et al. (1980) have pointed out, repeated measurements within a too short time period will produce, through the inflation and deflation

of the pressure cuff, temporary tissue changes which, in turn, will result in different blood pressure readings.

Has Research Coped With The Above Problem?

It can be concluded that, except for the study of Kasl and Cobb (1970), none of the other studies of stress at work and blood pressure, has adequately measured blood pressure. In some of the studies, blood pressure was measured only once (Brousseau & Mallinger, 1981; Crump, et al., 1981; House, et al., 1979; Howard, et al., 1976; Schär, et al., 1973; Shirom, et al., 1973; Waldorn, 1978). The study by Chapman et al. (1966) can also be included here. In this study, blood pressure was measured for several years, but only once each year. In other studies, blood pressure was measured several times; however, two or more of the measures were taken on only one occasion or during only one visit (Caplan, 1971; Caplan, et al., 1975; French & Caplan, 1970; Harburg, et al., 1979; Orth-Gomér & Ahlbom, 1980; Rose, et al., 1978).

Furthermore, in most of these studies, the several measures of blood pressure were taken repeatedly or during a short period of time. Thus, they were vulnerable to artificial results, as described by Stern, et al. (1980).

Direct Versus Indirect Measurement Of Blood Pressure--What Has Been Used And What Is Better? All of the studies on work stress and blood pressure have used indirect measures of blood pressure. The most common indirect measure of blood pressure employs a sphygmomanometer, which consists of a pressure cuff connected to a tube containing mercury. Using the indirect measure creates problems of reliability, such as the personal judgment of the experimenter about the presence or absence of korotkoff

sounds. The direct measure of blood pressure, through a catheter which is inserted into a blood vessel, seems to be a much more accurate method of recording blood pressure (Lywood, 1967). However, using such a technique, although it is technically more accurate than the indirect measure, might create an undesirable psychological stressor and increase resistance to future measurement.

SERUM CHOLESTEROL

1. Stable Or Permanent Factors That Might Affect Serum Cholesterol Levels

Familial Tendency--Why It Has To Be Taken Into Account. Researchers, such as Christian and Kang (1977), Hennekins, Levine, Rosner, Klein, Gourley, and Jesse (1980), Johnson, et al. (1965), Mayo, Fraser, and Stamtoyannopoulos (1969), and Schaefer, Aldersberg, and Steinberg (1958), have indicated that cholesterol levels in children are positively correlated with those of their parents and their siblings. Some of them have shown that approximately half of the variance in plasma cholesterol is genetic in origin. Some studies (Johnson, et al., 1965; Mayo, et al., 1969; Schaefer, et al., 1958) were able to avoid the problem of the possible influence of general socioeconomic factors operating within one family as being distinct from the others by showing no correlations between parental levels.

Sex--Why It Has To Be Taken Into Account. As Sabine (1977) has summarized, during childhood, adolescence, and young adulthood, there seems to be little difference in the level of cholesterol (e.g., Dyerberg & Hjorne, 1973). However, later in life, males tend to have a higher concentration of cholesterol, due to or at least accompanied

by, relative changes in the levels of very-low-density lipoproteins (VLDL) and low-density lipoproteins (LDL), although after 50 years of age this trend may be reversed (Aldersberg, Schaefer, Steinberg, & Wang, 1956; Fredrickson & Levy, 1972).

Age--Why It Has To Be Taken Into Account. In the human, plasma cholesterol generally rises rapidly after birth (the rate of rise depending on the diet), continues to rise slowly throughout life until about 50 years of age, when it levels off or falls slightly in men, but may continue to rise in women (Fredrickson, Levy, & Lees, 1967; Fredrickson & Levy, 1972; Whyte & Yee, 1958). It seems, as Sabine (1977) has pointed out, that genetic and/or environmental components are involved in this phenomenon.

Diet--Why It Has To Be Taken Into Account. There seems to be little doubt that the quantity and quality of fatty acids in the diet can profoundly influence the level of circulation cholesterol in men (Kinley & Krause, 1959; Sabine, 1977; Spirts, Ahrens, & Grundy, 1965). In addition, numerous studies (e.g., Keys, et al., 1960) have shown that there is a statistically significant difference in plasma cholesterol between people on cholesterol-containing and cholesterol-free diets. However, as indicated by Sabine (1977), plasma cholesterol in man does not change grossly with levels of dietary cholesterol. Thus, the quantity and quality of fatty acids are the most important factors that should be considered in research on cholesterol under stress.

Health Disorders--Why It Has To Be Taken Into Account. Sabine (1977) has pointed out that there are large numbers of inheritable diseases or disorders of lipid metabolism in man that influence the

level of cholesterol (e.g., cholesterol ester shortage disease, tangier disease). Also, there are non-inheritable diseases, such as liver disorders, that influence the level of blood cholesterol.

Has Research Considered The Above Factors?

Studies that have focused on the impact of stress at work on cholesterol in the blood (total number identified--14) usually have not taken into account the possible impact of these stable or permanent factors. Just a few of them have ruled out or taken into account the possible impact of the health conditions of subjects (Caplan, 1971; Chapman, et al., 1966; Rubin & Rahe, 1974), their diets (Chapman, et al., 1966; Friedman, et al., 1958), their ages (Caplan, et al., 1975; Crump, et al., 1981; Rubin & Rahe, 1974; Schar, et al., 1973; Shirom, et al., 1973), or their familial tendency (Caplan, 1971; Crump, et al., 1981; Rubin & Rahe, 1974; Schar, et al., 1973).

The sex variable has been generally controlled by the fact that most of the research on stress and cholesterol has dealt exclusively with males.

2. Transitory Factors That Might Affect Serum Cholesterol Levels

Seasonal Differences--Why They Have To Be Taken Into Account.

There is general agreement among scientists that the lowest levels of cholesterol occur in the autumn or winter, while the highest levels occur in the spring or summer (Fyfe, Dunnigan, Hamilton, & Rae, 1968; Sabine, 1977). Therefore, the impact of the seasonal factor on the validity of studies dealing with work stress and cholesterol depends to a considerable extent on the nature of the study. In the

case of longitudinal studies, in which blood was collected during different seasons, both the internal and external validity of the results might be seriously damaged. On the other hand, in studies where physiological data were collected over short periods of time (e.g., one season), the results might have higher internal validity, but they could not be generalized beyond the specific season, or compared with the results of studies conducted during any other season.

Smoking--Why It Has To Be Taken Into Account. Smoking before or during measurement tends to increase the level of blood cholesterol (Sabine, 1977).

Venous Occlusion--Why It Has To Be Taken Into Account. Venous occlusion, even for a short time period, can significantly increase the measured level of cholesterol (Koerselman, Lewis & Pilkington, 1961; Statland, Bokelund, & Winkel, 1974). Also, the second sample taken through the same venupuncture tends to show a slightly higher level of cholesterol than the first (Bokelund, Winkel, & Statland, 1974).

Postural Position--Why It Has To Be Taken Into Account. The level of cholesterol tends to be higher while standing up than while sitting (Statland, et al., 1974).

Has Research Considered The Above Factors?

Smoking, Venous Occlusion, And Postural Position--Except for Caplan et al. (1975), who ruled out the possible impact of smoking before measurement (because smoking was forbidden) and the postural position of the subjects (all were in the sitting position), none of the other studies that used cholesterol as a stress symptom considered (at least not explicitly) any of the above transitory factors.

Seasonal Differences--All the identified stress studies that have measured blood cholesterol of subjects in different seasons have not ruled out or taken into account the possible effects of the seasonal factor on the level of cholesterol (Caplan, et al., 1975; Chapman, et al., 1966; Cobb & Kasl, 1972; Friedman, et al., 1958; Gore, 1978; Rubin & Rahe, 1974). Thus, the internal validity of these studies and the ability to generalize or to compare their results with other studies is seriously questioned.

In relation to studies that have collected blood samples in only one season, usually there has been no indication of the specific season in which the blood samples were taken. However, it is reasonable to assume that not all studies were done in the same season; thus, again, the very limited ability to generalize or to compare the results with other studies.

CATECHOLAMINES

1. Stable Or Permanent Factors That Might Affect Catecholamine Levels

Health Disorders--Why They Have To Be Taken Into Account. Some physical disorders were found to influence catecholamine levels in subjects, especially adrenaline or noradrenaline; among them, hypoglycemia and hypertension (Frankenhaeuser, 1975).

Sex Differences--Why They Have To Be Taken Into Account. It has been generally assumed that, when catecholamine exertion is expressed in relation to body weight, no difference remains in excretion rate between the sexes. However, as Frankenhaeuser (1973) and her associates (Johnson, 1972; Johnson & Post, 1972) showed, a somewhat different result is obtained, at least with regard to adrenaline excretion, when

the sexes are compared under psycho-social pressures. Frankenhaeuser (1975) has stated that these studies are "tentatively indicative that underenomedullary activity is a less sensitive indicator of behavioral arousal in females than in males." (p. 90)

Has Research Considered The Above Factors?

Nine studies were identified that explored the impact of work stress on catecholamine levels. Out of that group, only Rubin (1974) controlled for the health conditions of his subjects, noting that all were "in excellent health during the time of the study." The impact of sex (if there is such an impact) was controlled, since all of the catecholamine studies dealt with males only.

2. Transitory Factors That Might Affect Catecholamine Levels

As Christie and Woodman (1980) have noted, there is a wide range of both external and internal stimuli that can cause changes in urinary catecholamine adrenaline and noradrenaline secretion and excretion; these include the following:

Time Of Day--Why It Has To Be Taken Into Account. The time when the urine sample is taken tends to have a significant impact on the level of catecholamines. Thus, for example, it was found that at night urine values of noradrenaline were 50 percent lower, while adrenaline concentrations were reduced by 10 percent.

Postural Position--Why It Has To Be Taken Into Account. Plasma values, which also have been reflected in urine, tend to increase on changing from a supine position to a standing position.

Physical Exertion (shortly before the measurement)--Why It Has To Be Taken Into Account. This tends to increase the urinary noradrenaline.

Tea, Coffee, and Cocoa Drinking, Cigarette Smoking, etc. (shortly before measurement)--Why They Have To Be Taken Into Account. Intake of these substances may result in the production of materials which interfere with the biochemical analysis of catecholamines.

Has Research Considered The Above Factors?

Some of the studies of stress and catecholamines have paid reasonably sufficient attention to the impact of the above transitory factors, while others have not. Dutton, et al. (1978), Frankenhaeuser and Gardell (1976), Jenner, et al. (1980), and Johansson, et al. (1978) have compared the levels of catecholamines in their subjects during a work day and during a rest day. In order to control for the time of measurement, urine samples were collected during different hours of both the work day and the rest day.

Dutton, et al. (1978) did even more than that; they collected 24 hourly urine samples from their subjects (firemen and paramedics), both during the work day and the rest day. In order to control for postural position and physical exertion, the subjects in the above studies were instructed not to sleep and to avoid excessive mental and physical effort during the rest day. To control for the consumption of caffeine and nicotine, the subjects were instructed to either restrict or refrain from the consumption of caffeine and nicotine during the work day and the rest day (Dutton, et al., 1978; Frankenhaeuser & Gardell, 1976), to keep a detailed record of their coffee and tea drinking

(Frankenhaeuser & Gardell, 1976; Jenner, et al., 1980), or to keep the levels of tea, coffee, and cocoa drinking and cigarette smoking during the rest day at the same level as it was during the work day (Frankenhaeuser & Gardell, 1976; Johansson, 1978).

However, as mentioned earlier, other studies failed to consider or rule out the possible impact of some or all of the identified transitory factors. Astrand, et al. (1973) found that the level of catecholamines in fishermen during their daytime work hours was significantly higher than during rest hours at night. However, as the authors themselves admit, it was not possible to know if, and to what extent, the physical and mental stress of the fishermen at work influenced or caused this difference. It might well be that this difference was caused by having the urine collected at different times (day versus night), or when there was a difference in body posture (lying at night versus sitting or standing during the day).

The studies of Hale, et al. (1971a) and Rubin (1974) suffer also from a similar methodological problem. Hale, et al. (1971a) compared the level of urinary catecholamines during the evening shift (between 1500 and 2300 hours), which was considered the most stressful period, with the level of urinary catecholamines on the early morning shift (between 2300 and 0700 hours). Rubin (1974) collected the urine of pilots and radar intercept officers once during a control rest day and once after performing tasks in the day or night. Thus, in both studies, the comparisons seem invalid because of the different times of urine collection. In addition, the level of caffeine and nicotine consumption before measurement was not taken into account in the studies of

Astrand, et al. (1973), Grandjean, et al. (1971), Hale, et al. (1973a,b) and Rubin (1974).

3. Procedural Factors in Measurement That Might Affect Catecholamine Levels

Here we will focus on hormone fluctuations as a major fundamental obstacle to the valid analysis and interpretation of biochemical measurements.

The Problem Of Hormone Fluctuations. As Christie and Woodman (1980) have noted, many hormones in the blood, such as catecholamines and cortisol, have a half-life that can be measured in seconds. Fluctuations can be so fast that the results supplied by a single sample, or samples taken at intervals of several hours, can be highly variable, depending upon the point(s) in the sequence of secretion-action-cataclysm the people were in when examined. Thus, the appropriate solution seems to be to take a few blood samples for analysis during a relatively short period of time.

Has Research Coped With The Above Problem?

As noted earlier, all of the identified studies of work stress and catecholamines have measured the level of catecholamines in the urine. The measurement of biochemicals in the urine, as will be elaborated upon in the discussion and conclusions section of this paper, seems to be a much more valid and reliable indicator of stress than the measurement of biochemicals in the blood. Thus, one might assume or conclude that work stress researchers have focused on catecholamine levels in the urine as a stress indicator, mainly because of their awareness of the reliability and validity problems of physiological measurement.

However, in order to examine the above assumption further, it was decided to widen the focus of our investigation to those studies that had used cortisol as an indicator of work stress. It was found that most researchers had measured the cortisol in their subjects' blood. (Only three of nine studies, those of Hale, et al. (1971a,b) and Bourne, et al. (1968) had measured the cortisol in the urine.) From the remaining six studies, only Rose, et al. (1978) coped with the problem of fluctuations in measurement by collecting blood samples from his subjects continuously over several periods. Caplan (1971), Caplan and Cobb (1979), Marchbanks, et al. (1963), Rubin and Rahe (1979), and Rubin (1979) collected only one sample of blood. Caplan, et al. (1975) collected two samples at 20 minute intervals. This does not adequately address the problem. Such a procedure tends to raise serious questions about the general knowledge and understanding of researchers in the analysis of biochemicals as measures of work stress.

PEPTIC ULCER

1. Stable Or Permanent Factors That Might Affect The Occurrence Of Peptic Ulcer

Longitudinal Consumption Of Caffeine and Nicotine--Why They Have To Be Taken Into Account. There is some evidence to suggest that the consumption of caffeine (including caffeinated colas) and nicotine over long periods of time increases the incidence of duodenal ulcer, which is (as will be discussed later) a certain type of peptic ulcer (see Chapman, 1978, and Wolf, et al., 1979).

Familial or Genetic Factors--Why They Have To Be Taken Into Account. Chapman (1978), Wolf, et al. (1979) and Yager and Weiner (1971) have

mentioned important genetic factors that might influence the creation and persistence of peptic ulcer. In short, research on these factors has suggested that peptic ulcer tends to occur 2 to 2½ times as frequently among the living siblings of patients with ulcer as among the general population (Doll & Kelloch, 1951; Habbick, 1968; Vesely, 1968); there is a higher rate of concordance for duodenal ulcer among monezygous (three times as often) than among dizygous male twins (Jensen, 1972); and that those subjects with blood group O are about 37 percent more likely to develop duodenal ulcer than are people of other groups. Also, those nonsecretors of blood group substances in their saliva are 50 percent more likely to develop duodenal ulcer (Hanley, 1964; Marcus, 1969; Sievers, 1959; Vesely, 1968).

Has Research Considered The Above Factors?

Eight studies were identified as having examined the impact of work stress on peptic ulcer. None of these studies ruled out or took into consideration the possible influence of the above mentioned factors on the relationship between stress at work and peptic ulcer.

2. Procedural Factors In Measurement That Might Affect The Occurrence of Peptic Ulcer

Studies of stress and peptic ulcer seem to suffer from two major problems that threaten their validity: (1) the lack of a commonly accepted definition of what peptic ulcer is, and (2) the vagueness of criteria regarding peptic ulcer illness. These problems will be elaborated upon now.

Problem Of Peptic Ulcer Definition--As Wolf, et al. (1979) have pointed out, peptic ulcer is the result of a group of heterogeneous diseases of diverse etiology and patogenesis, rather than a single disease. They have pointed out, further, that a gastric ulcer is not identical to a duodenal ulcer, and that these two types of ulcers should be separated in research.

Has Research Coped With The Above Problem?

Out of the eight identified studies, only two studies (Cobb & Rose, 1973; Sandberg & Bliding, 1976) have dealt explicitly with duodenal ulcer. Other studies (Caplan & Cobb, 1970; Dunn & Cobb, 1962; Cobb & Kasl, 1972; Gosling, 1958; House, et al., 1979; and Johansson, et al., 1978) either seemed to be dealing with both types of ulcers, or were not specific as to what type of disease they were discussing.

Problem Of Vague Criteria Of Peptic Ulcer Illness--Wolf, et al. (1979) have noted that there seems to be some disagreement as to what evidence should be required for diagnosing an ulcer illness: patient symptoms, doctor diagnosis, radiological evidence, or surgical evidence. Each of these has its special problems. To illustrate, acceptance of symptoms alone as a diagnostic criterion would tend to overstate the existence of the illness. The use of evidence from only surgery, on the other hand, would seriously understate its existence (Wolf, et al., 1979).

Has Research Coped With The Above Problem?

Studies have tended to ignore the criteria problems by arbitrarily choosing their own criteria for defining the treating peptic ulcer.

House, et al. (1979) and Caplan, et al. (1975), for example, relied on the subject's self report to determine the existence of peptic ulcer. Dunn and Cobb (1962), Johansson (1978), Gosling (1958), and Sandberg and Bliding (1976) relied both on the subject's report and on some medical evidence. Johansson, et al. (1978) used certain chemical tests, Dunn and Cobb (1962) checked the level of serum pepsinogen in the blood, Gosling (1958) used a radiographic examination, and Sandberg and Bliding (1976) used medical records, as well as information from fellow trainees and platoon commanders, to determine the existence of peptic ulcer. Cobb and Rose (1973) based their judgment of peptic ulcer on cases among air traffic controllers on a review of aeromedical certification examinations.

DISCUSSION AND CONCLUSIONS

The central message of this paper is that adequate methods and procedures for the measurement of physiological symptoms are important to both the internal and external validity of work stress studies, a fact that most researchers to date have ignored or to which they have paid insufficient attention.

We are aware that our emphasis on improving the methods and procedures of physiological measurement can be challenged, because of a claim that not all of the various threatening factors which we have discussed and believe should be considered in the physiological measurement process are, in reality, that critical. This is based on the assumption that, in an adequately designed work stress experiment, not all of these factors are important or equally important to measurement validity.

Our counter claim is that a proper analysis of the relative importance or relative effects of the different threatening factors on the work stress-physiological symptoms relationship is not feasible at this time, because of the following reasons:

1. As can be seen from Table 2, except for cardiovascular symptoms, all the other identified symptoms, in general, have not been researched to a sufficient extent to establish the existence of a valid link between them and stress at work. Also, a portion of these studies are characterized by small to very small samples. Thus, even if we had information about the various symptomatic outcomes resulting from work stress, we probably still would not have sufficient information to draw adequate, valid conclusions and to generalize our findings.

2. Table 2 clearly summarizes what has been argued in this paper; that a significant number of the potentially threatening factors identified by us have not been controlled or taken into account <u>at all</u> (or only to a limited extent) in all (or nearly all) of the examined studies.

3. Among the studies that have considered the possible effects of the threatening factors, only a few of them have gone about it in a way that would contribute sound empirical information regarding the effects of these factors on the focal physiological symptom or symptoms. Most studies have failed to provide such empirical information, due to the fact that they simply omitted them on an a priori basis (deliberately or unintentionally), and thereby the possible influence of these factors on the results. A simple, striking example of this phenomenon is the fact that all of the mentioned studies have dealt exclusively, or almost exclusively, with males.

4. One suggestion might be to match and then compare the results of studies that, through some a priori process, controlled for one or more of the threatening factors. Such a suggestion has serious limitations, because of the unsystematic manner in which the various factors have been controlled. Consequently, the possibility of reaching even tentative conclusions regarding the effects of one controlled factor from the potential effects of another controlled factor is essentially eliminated.

5. It is assumed that different types or sources of work stress might have different effects on the various physiological symptoms, although sufficient knowledge to indicate the specific effects of a given source or sources of stress on a given physiological symptom is lacking. (See reviews by Beehr & Newman, 1979, and Schuler, 1980.) This implies that an analysis of the possible effects of the threatening factors on physiological symptoms (including those discussed here) should be based on a process of matching and comparing studies, not just in regard to the examined physiological symptoms, but also in regard to their source or sources of work stress. There exists, however, the realistic possibility that the effects of the threatening factors on the various physiological symptoms might not be solely independent, but linked or interactive, at least partly, with the different situations or sources of stress to which subjects have been exposed. The fact that studies have examined the effects of broad and different types and sources of stress in different work settings on different physiological outcomes means that the ability to analyze the relative effects of the threatening factors is very limited, at best.

From the above, it seems clear that one cannot reach valid, general conclusions about the relative importance or effects of the threatening factors on the accuracy of the measurement of physiological symptoms in work stress research. It is hoped that, in the future, sufficient attention will be given to this matter in guided, programmatic research in order to begin to map the effects of the different factors on the work stress-physiological symptoms relationship.

The normative conclusion of this paper, that much greater attention should be given to the validity of physiological measurement in work stress research, leads us to the following three recommendations:

1. Researchers in the future should raise their standards in regard to the methods and procedures they use for measuring physiological symptoms. This goal may not be easy to accomplish, considering all of the complex issues the researcher has to consider. It seems to be a necessary step, however, in order to avoid invalid or confusing interpretations and conclusions about the relationship between stress at work and physiological symptoms.

2. The professional journals, in turn, should attempt, through the paper review process, to require improved approaches to the measurement of physiological symptoms. Of the criteria used to make accept/reject decisions about submitted papers, journals that publish research on organizational and occupational stress have tended, it seems, to give considerable emphasis to such methodological issues as the adequacy of the general research design and the application of appropriate statistical techniques, but have tended not to give sufficient emphasis to this particular matter.

3. Finally, consideration should be given to the question of which of the physiological symptoms one should give further attention. As noted in this paper (see also Table 2), most studies have tended to use cardiovascular symptoms for assessing the level of stress at work. Based on our review of the literature, we suggest a shift toward the measurement of biochemicals in the urine as perhaps supporting a number of more valid and reliable indices of stress at work. In order to justify this recommendation, we shall first briefly describe the major problems of using cardiovascular symptoms, peptic ulcer, and abnormal levels of biochemicals in the blood as indices of stress at work, and then elaborate upon the advantages of using urinary biochemicals.

Major Problems With Cardiovascular Symptoms. The major problem with cardiovascular symptoms is their high sensitivity to transient events, which do not necessarily relate to the common, prevalent work stressors that are supposed to be measured. Lynch, Long, Thomas, Malinow, and Katcher (1981), for example, have shown that even talking during the process of blood pressure measurement tends to affect people's levels of blood pressure. In another laboratory study, Drescher, Gantt, and Whitehead (1980) found a systematic, significant decrease in heart rate when the experimenter touched the subject's wrist, in comparison with other situations when the experimenter was outside the room or in the room without touching the subject. Such examples indicate how difficult it is to control all the possible transient variables that might affect the measures of cardiovascular symptoms. One might suggest that using the direct technique to measure

blood pressure (direct arterial connulation), instead of the common indirect measurement, would reduce the instability of the results. This might only be partially true, since, as was mentioned earlier, the direct technique might create undesirable psychological stress and thereby alter the blood pressure level, as well as significantly reduce the willingness of employees to participate in future research.

Major Problems Of Peptic Ulcer. Peptic ulcer is a physiological symptom that usually develops over a period of years. Thus, even if peptic ulcer can serve as an index of an enduring, long-term stressful situation, it certainly cannot be a valid criterion by which to consider any short-term period of stress. As applied researchers, we need indices that reflect the existence of stressors as close to their sources as possible, in order to try to remove them or reduce their negative impacts on work behavior. Thus, although peptic ulcer might have merit (assuming the definitional problems can be solved), other symptoms, it seems, should generally be used in work stress research.

Major Problems Of Biochemicals In The Blood. Similar to the process of direct measurement of blood pressure, the process of blood collection may create an undesirable source of stress (Christie & Woodman, 1980). The resistance of subjects is assumed to be even greater because of the need to collect several blood samples during a short period of time to assure valid results. Thus, the use of biochemicals in the blood as criteria by which to study work stress is not very practical.

Advantages Of Biochemicals In The Urine. In contrast to the above, measuring biochemicals in the urine is characterized by three important advantages:

1. The collection of urine samples, in comparison to the collection of blood samples and the measurement of blood pressure by the direct technique, is potentially less obtrusive to subjects.

2. It is easy to collect urine samples at the workplace without interrupting the work process. In contrast to the methods for measuring blood pressure or collecting blood samples, there is no need for external intervention. (See Frankenhaeuser & Gardell, 1976.)

3. In addition (and this is an important advantage), urinary metabolites tend to be significantly more stable and less sensitive to transient events. (Jenner, 1979; Dimsdale & Moss, 1980.) To illustrate, urinary catecholamines represent an integrated measure of excretion over a one to four hour period. Plasma catecholamines, on the other hand, reflect a subject's experiences just prior to sampling, including possible anxiety regarding the sampling process itself (Jenner, et al., 1979).

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TABLE 1

Summary: Physiological Symptoms in Studies of Work Stress

	Cardiovascular symptoms		Biochemical symptoms				Gastrointestinal symptoms
	B.P.	C.A.	Chol.	Cat.	Cort.	U.A.	P.U.
Astrand, et al. (1973)	-	+	-	+	-	-	-
Aunola, et al. (1979,78)	-	+	-	-	-	-	-
Barnard & Duncan (1973)	-	+	-	-	-	-	-
Bourne, et al. (1968)	-	-	-	-	+	-	-
Brousseau & Mallinger (1981)	+	+	-	-	-	-	-
Caplan (1971)	+	-	+	-	-	+	-
Caplan & Jones (1975)	-	+	-	-	-	-	-
Caplan, et al. (1975)	+	+	+	-	+	+	+
Caplan, et al. (1979)	-	-	-	-	+	-	-
Chapman, et al. (1966)	+	-	+	-	-	-	-
Cobb & Kasl (1972)	+	-	+	-	-	+	+
Cobb & Rose (1973)	+	-	-	-	-	-	+
Crump, et al. (1981)	+	-	+	-	-	-	-
Dougherty (1967)	+	+	-	-	-	-	-
Dutton, et al. (1978)	-	-	-	+	-	-	-
Dunn & Cobb (1962)	-	-	-	-	-	-	+
Frankenhaeusr & Gardell (1976)	-	-	-	+	-	-	-
French & Caplan (1970)	+	+	+	-	-	+	-
Friedman, et al. (1958)	-	-	+	-	-	-	-
Gore (1978)	-	-	+	-	-	-	-
Gosling (1958)	-	-	-	-	-	-	+
Grandjean, et al. (1971)	-	-	-	+	-	-	-
Hale, et al. (1971a)	-	-	-	+	+	-	-
Hale, et al. (1971b)	-	-	-	+	+	-	-
Harburg, et al. (1979)	+	-	-	-	-	-	-
Hennigan & Wortham (1975)	-	+	-	-	-	-	-
House, et al. (1979)	+	-	-	-	-	-	+
Howard, et al. (1976)	+	-	+	-	-	+	-
Jenner, et al. (1980)	-	-	-	+	-	-	-
Johansson, et al. (1978)	-	-	-	+	-	-	+

TABLE 1 (continued)

Summary: Physiological Symptoms in Studies of Work Stress

	Cardiovascular symptoms		Biochemical symptoms				Gastrointestinal symptoms
	B.P.	C.A.	Chol.	Cat.	Cort.	U.A.	P.U.
Kasl & Cobb (1970)	+	-	-	-	-	-	-
Korinka & Korhonen (1981)	-	+	-	-	-	-	-
Marchbanks, et al. (1963)	-	-	-	-	+	-	-
Orth-Gomér & Ahlbom (1980)	+	-	+	-	-	+	-
Reeder, et al. (1973)	-	+	+	-	-	-	-
Reynolds (1974)	-	+	-	-	-	-	-
Rose, et al. (1978)	+	+	-	-	+	-	-
Rubin (1974)	-	-	-	+	+	-	-
Rubin & Rahe (1974)	-	-	+	-	+	+	-
Sales (1970)	-	+	-	-	-	-	-
Sandberg & Bliding (1976)	-	-	-	-	-	-	+
Schär, et al. (1973)	+	-	+	-	-	-	-
Shirom, et al. (1973)	+	+	+	-	-	+	-
Waldron (1978)	+	+	-	-	-	-	-
Warheit (1974)	-	+	-	-	-	-	-

Abbreviations:

B.P. - Blood Pressure
C.A. - Cardiac Activity
Chol. - Cholesterol
Cat. - Catecholamines
Cort. - Cortisol
U.A. - Uric Acid
P.U. - Peptic Ulcer

Note: Total number of studies reviewed - 45.

TABLE 2

Summary: Studies of Work Stress Concerned with the Effects of Threatening Factors on Physiological Symptoms

Cardiovascular Symptoms

	Race	Sex	Age	Familial Tendency	Health Conditions	Postural Position	Consumption of Caffeine and Nicotine*	Humidity	Alcohol Consumption	B.P. Variability	B.P. Technique of Measure
Astrand, et al. (1973)	?	+	+	-	-	-	-	-	-	-	-
Aunola, et al. (1978,1979)	+	+	+	-	-	-	-	-	-	-	
Bernard & Duncan (1975)	?	+	-	-	+	-	-	-	-	-	-
Broussean & Mallinger (1981)	+	+	+	-	-	-	-	-	-	-	-
Caplan (1971)	+	+	+	+	+	-	-	-	-	-	-
Caplan & Jones (1975)	?	+	-	-	-	+	-	-	-	-	-
Caplan, et al. (1975)	+	+	+	-	-	+	+	-	-	-	-
Chapman, et al. (1966)	?	+	-	-	+	-	-	-	-	-	-
Cobb & Kasl (1972)	?	+	-	-	-	-	-	-	-	-	-
Cobb & Rose (1973)	+	+	+	-	-	-	-	-	-	-	-
Crump, et al. (1981)	?	+	+	+	-	-	-	-	-	-	-
Dougherty (1967)	?	+	+	-	-	-	-	-	-	-	-
French & Caplan (1970)	?	+	-	-	-	-	-	-	-	-	-
Harburg, et al. (1979)	+	+	+	-	-	-	-	-	-	-	-
Hennigan & Wortham (1975)	?	+	+	-	+	-	-	-	-	-	-
House, et al. (1979)	+	+	-	-	-	+	-	-	-	-	-
Howard, et al. (1976)	?	+	-	-	-	-	-	-	-	-	-
Kasl & Cobb (1970)	+	+	-	-	-	-	-	-	-	+	-
Kourinka & Korhonen (1981)	+	+	+	-	+	-	-	-	-	-	-
Orth-Gomer & Ahlbom (1980)	?	+	-	+	+	+	-	-	-	-	-
Reeder, et al. (1973)	+	+	+	-	-	-	-	-	-	-	-
Reynolds (1974)	+	+	+	-	+	-	-	-	-	-	-
Rose, et al. (1978)	?	+	-	-	-	+	-	-	-	-	-
Sales (1970)	?	+	-	-	-	-	-	-	-	-	-
Schar, et al. (1973)	+	+	+	+	-	-	-	-	-	-	-
Shirom, et al. (1973)	+	+	+	-	-	-	-	-	-	-	-
Waldron (1978)	+	+	-	-	-	-	-	-	-	-	-
Warheit (1974)	+	+	+	-	+	-	-	-	-	-	-

* Before or during measurement.

Summary: Studies of Work Stress Concerned with the Effects of Threatening Factors on Physiological Symptoms

Serum Cholesterol

	Sex	Age	Familial Tendency	Health Condition	Diet	Postural Position	Consumption of Caffeine*	Season	Venous Occlusion
Caplan (1971)	+	-	+	+	-	-	-	+	-
Caplan, et al. (1975)	+	+	-	-	-	+	+	-	-
Chapman, et al. (1966)	+	-	-	+	+	-	-	-	-
Cobb & Kasl (1972)	+	-	-	-	-	-	-	-	-
Crump, et al. (1981)	+	+	+	-	-	-	-	+	-
French & Caplan (1970)	+	-	-	-	-	-	-	+	-
Friedman, et al. (1958)	+	-	-	-	+	-	-	-	-
Gore (1978)	+	-	-	-	-	-	-	-	-
Howard, et al. (1976)	+	-	-	-	-	-	-	+	-
Orth-Gomer & Ahlbom (1980)	+	-	-	-	-	-	-	+	-
Reeder, et al. (1973)	+	-	-	-	-	-	-	+	-
Rubin & Rahe (1974)	+	+	+	+	-	-	-	-	-
Schar, et al. (1973)	+	+	+	-	-	-	-	+	-
Shirom, et al. (1973)	+	+	-	-	-	-	-	+	-

Catecholamines

	Sex	Health Conditions	Time of Day	Postural Position	Consumption of Caffeine and Nicotine*	Physical Exertion
Astrand, et al. (1973)	+	-	-	-	-	-
Dutton, et al. (1978)	+	-	+	+	+	+
Frankenhaeuer & Gadell (1976)	+	-	+	+	+	+
Grandjean, et al. (1971)	+	-	-	-	-	-
Hale, et al. (1971a)	+	-	-	-	-	-
Hale, et al. (1971b)	+	-	-	-	-	-
Jenner, et al. (1980)	+	-	+	+	+	+
Johansson, et al. (1978)	+	-	+	+	+	+
Rubin (1974)	+	+	-	-	-	-

*Before or during measurement.

TABLE 2 (continued)

Summary: Studies of Work Stress Concerned with the Effects of Threatening Factors on Physiological Symptoms

	Peptic Ulcer			
	Familial Tendency	Longitudinal Consumption of Caffeine and Nicotine	Peptic Ulcer Definition	Peptic Ulcer Illness Criteria
Caplan, et al. (1971)	-	-	-	-
Cobb & Kasl (1972)	-	-	-	-
Cobb & Rose (1973)	-	-	+	-
Dunn & Cobb (1962)	-	-	-	-
Gosling (1958)	-	-	-	-
House, et al. (1979)	-	-	-	-
Johansson, et al. (1978)	-	-	-	-
Sandberg & Bliding (1976	-	-	+	-

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